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Zambia has until recently relied almost 100% on hydropower for electricity generation. The first coal power plant in Zambian history was commissioned recently in 2016/17. An unprecedented power shortfall in 2016 prompted the Zambian government to diversify its energy sources by planning to go into solar and increased coal power. Coal causes high levels of pollution, degrades the environment, damages people's health and causes climate change. Solar and other renewable sources of energy are clean. The cost of power from renewable energy is now competitive with that of coal power. Coal power is on the decline worldwide and renewable power is on the increase. Global climate change policies will become more stringent and coal will have no place in a sustainable energy future. Zambia therefore needs to rethink its policy of increased coal power.

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1. Introduction

Zambia has historically relied heavily on wood fuel (firewood and charcoal), which accounts for about 70% of its total energy consumption. Electricity accounts for about 20% of the total energy mix. Only about 25% of the overall population and 5% of the rural population has access to electricity. Since independence in 1964 until recently, Zambia relied almost completely on hydropower for electricity generation, mainly from the three hydropower plants in Kafue Gorge, Kariba North and Livingstone, with installed capacities of 900 MW, 600 MW and 108 MW, respectively. Having been in existence since 1908, Livingstone is the oldest power plant in Zambia, followed by Kafue Gorge and Kariba North which were commissioned in 1973 and 1976, respectively. The total installed capacity in Zambia remained static at 1,650 MW for three decades until 2009. Low economic growth during the 1980s and 1990s led to nearly stagnant electricity consumption, below the installed capacity. This led to complacent thinking that Zambia had abundant electricity. Electricity tariffs were highly subsidised and non cost-reflective. No new power plants were set up, as they did not make economic sense in this scenario.

2. Meeting the Escalating Power Demand

Electricity is at the core of all economic activities. Increased economic growth during the past two decades has resulted in rapidly escalating demand for electricity in Zambia. This prompted the upgrading and extension of existing power plants. The capacity of each of the six units at Kafue Gorge plant was upgraded from 150 MW to 165 MW i.e. from a total of 900 MW to a total of 990 MW in 2009. Subsequently, the four units of 150 MW each at Kariba North were upgraded to 180 MW in 2012, pushing the total generating capacity from 600 MW to 720 MW. An extension was done by adding two more units of 180 MW each in 2013/2014, taking the total installed capacity at the Kariba North to 1,080 MW. In a joint venture between Tata Power and ZESCO, an additional 120 MW of hydropower was commissioned in 2016 on the Itezhi-Tezhi dam.

As the demand for electricity came to outstrip capacity, the country started looking into other sources of energy. A 80 MW Copperbelt Energy Corporation (CEC) gas turbine (used as stand by) and 50 MW heavy fuel oil (HFO) based power plant at Ndola Energy commissioned in 2014 are among the first fossil fuel based plants in Zambia. Another 57 MW HFO plant by Ndola Energy was commissioned recently in 2017.

The first coal power plant in the Zambian energy sector came with the commissioning of a total of 300 MW of coal power during 2016/2017 at Maamba, in two stages of 150 MW each. The power plant is a joint collaboration between Nav Bharat of India and Zambian utility ZESCO, which has a power purchase agreement to buy power at an average tariff of about $10 cents/kWh.

3. Acute Power Deficit, Impacts and Mitigation

The low rainfall in Zambia during the 2015/2016 season, leading to much lower hydropower generation, exacerbated the creeping power shortfall and caused unprecedented massive and continued power outages throughout the country during 2016. The impact was severe and immediate. Industries, including the mining industry which has been the backbone of the Zambian economy, suffered heavily, as did household consumers. Use of high-cost and polluting diesel generators skyrocketed, costly power imports stretched government resources and depleted foreign exchange reserves, and the national GDP growth plummeted from around 7% to 3.4%. This was a major wake up call.

Stung by the severe impacts of power shortfall during 2015/2016, the government moved swiftly to address the issue. An immediate mitigating measure was to import power from various sources, which included very costly diesel power. This cost the nation hundreds of millions of dollars annually. In order to mitigate power shortfalls and reduce its vulnerability to rainfall dependent hydropower, the government of Zambia not only embarked on additional hydropower projects, but also expedited the exploitation of new sources of power, as well as measures to attract private investors into power generation.

3.1 More Hydropower

Hydropower has long been the mainstay of Zambian electricity generation. The nation boasts over 6,000 MW of potential hydropower, of which less than half is currently exploited. It is unsurprising to look towards exploiting some of the remaining hydropower potential. A number of initiatives in this direction have been taken. This includes a 750 MW hydropower Kafue Gorge Lower (KGL) power plant, which started construction in 2015 and is projected to be completed in 2019 (http://www.power-technology.com/projects/kafue-gorge-lower-kgl-power-station/). KGL will be the third biggest power plant in Zambia. Its total cost including financing is $2 billion. It is being developed under the public private partnership (PPP) model on Build, Own, Operate and Transfer basis between ZESCO and Synohydro Corporation of China. The project is being financed by the Zambian government and foreign financial institutions, which include Exim Bank of China.

Another important initiative taken by the government of Zambia is the construction of the 2,400 MW (1,200 MW each for Zambia and Zimbabwe) Batoka Gorge hydropower plant to be located 54 kilometres downstream of the Victoria Falls. The governments of Zambia and Zimbabwe have appointed the African Development Bank (AfDB) in April 2017 as lead coordinator for the project, which is estimated to cost $6 billion (http://www.hydroworld.com/articles/2017/04/afdb-named-lead-coordinator-for-2-400-mw-batoka-gorge-hydropower-project-in-africa.htm). The construction is expected to begin in 2017/2018. A 1,200 MW hydropower plant on the Luapula River and a smaller 86 MW hydropower plant on the Lusiwasi River are other projects on which government is working, in addition to several other initiatives on mini hydropower projects.

3.2 Solar Power

For the first time Zambia through the Industrial Development Corporation (IDC) teamed up with the World Bank Group to embark on a new Scaling Solar Program, which is meant to make it easier for governments to quickly procure and develop large-scale solar power projects with private financing. Zambia has signed an agreement with the World Bank Group to develop a total of 600 MW solar power in three stages. In Round 1 in May 2016, successful auction for 2 x 50 MW was held. French developer Neoen S.A.S. and American solar power company First Solar were successful at a bid price of $6.02 cents/kWh (http://www.idc.co.zm). They have signed a 25-year power purchase agreement (PPA) with the national utility ZESCO to sell power at this cost, which will remain fixed for the duration of 25 years. Italian developer Enel Green power was the other winner at a cost of $7.84 cents/kWh. These PPAs are said to be the lowest prices for solar power in the whole of Africa (www.idc.co.zm).

IDC has embarked on Round 2 of the Scaling Solar program in Zambia, by inviting Expressions of Interest in March 2017 for 150 MW – 250 MW solar power. Later in 2017, Round 3 will invite bids for the remaining 300 MW. Since utility scale solar power can be deployed in a much shorter time of about one year from the start of construction, this would mean that Zambia should have a total of 600 MW of commissioned solar power by

2019. This will undoubtedly be a significant addition to its energy mix, at a very favourable cost.

3.3 More Coal Power

At a time when Zambia was craving to get power from any source, the commissioning of Maamba coal-fired power plant in 2016/2017 was a welcome development, as it relieved the country from the most severe load shedding in its history. Without this addition to the national grid, the power outages would have been of longer duration and the bills for power imports much higher. By providing the country with a diversified base load power at a critical time, the 300 MW Maamba coal power plant marks a milestone in Zambian electricity generation history.

Zambia now plans to produce more power from coal using its vast coal reserves in Maamba collieries. The capacity of the Maamba coal plant is planned to increase from the current 300 MW to 600 MW and further to 900 MW to meet the escalating power demand in the country. Additionally, another coal power plant is planned by EMCO Energy Zambia, a subsidiary of the India based EMCO Energy, with a total capacity of 600 MW in two phases of 300 MW each in the same region. The plant is nearing financial closure and is expected to be completed by 2020. More coal power plants are on the cards. Recently, Zambia signed a treaty with Mozambique for the setting up of a 1,200 MW coal power plant in the coal-rich province of Tete, to bolster electricity supply to both countries. It appears Zambia is fully on path to exploiting coal power for electricity generation to add to its arsenal of power sources.

3.4 Moving Towards Cost-Reflective Tariffs

The total installed power capacity in Zambia remained static during the 1980s and 1990s at about 1,650 MW and electricity tariffs were low compared to their cost. The need to move to cost reflective tariffs was recognised and echoed on various forums including the SADC ministerial conferences, but did not come into practice. At the 34th Meeting of SADC Energy ministers held in Sandton, Johannesburg on 24 July 2015, it was noted that so far only Namibia and Tanzania had reached cost reflective tariffs. The ministers readjusted the time frame of their previous decisions and reaffirmed their commitment to ensure that the SADC region reaches full cost reflective tariffs by 2019 (http://www.gov.za/speeches/34th-meeting-sadc-energy-ministers-24-jul-2015-0000).
The acute power shortfall of 2015/2016 proved to be a blessing in disguise, as it expedited government's resolve to move to cost reflective tariffs, which were implemented in May 2017. This measure would help to attract much needed private sector investment in the power sector.

4. Merits and Demerits of Different Sources of Power

While it is legitimate for Zambia to meet its current power demand through additional power sources, there is need for the country to be conscious of long-term sustainability, by looking holistically at economic, social, health and environmental implications.

4.1 Cost

Cost is an important parameter to be considered when making a choice on the source of power. The cost of renewable energy (solar and wind) has come down dramatically in recent years, so as to enable these sources to compete with conventional energy sources, such as coal and hydro. The average cost of electricity from Maamba is about $10 cents/kWh. On the other hand, the two recent successful bidders for solar power will sell electricity to ZESCO at $6.02 cents/kWh and $7.84 cents/kWh over a period of 25 years without any escalation of costs.

In order to provide a comparison of costs in the region, levelised cost of electricity (LCOE) from Escom's coal-fired power plants in South Africa is estimated at R1.05/kWh from Medupi coal power plant and R1.16/kWh from Kusile coal power plant. The cost of negative health effects and other cost externalities of coal-fired power generation are not included in these costs (http://www.ee.co.za/article/understanding-cost-electricity-medupi-kusile-ipps.html). On the other hand, the average price paid by Escom in Bid Window 4 is R0.69/kWh for wind energy and R0.87/kWh for solar photovoltaic (PV), making renewable energy a clearly cheaper option.

The capital cost of coal power plants is essentially unchanging over time, whereas the cost of renewable energy continues to fall. Therefore, renewable energy would remain preferable or at least competitive on the basis of costs alone. Another advantage of solar power is the rapidity with which it can be deployed. The time to commission a solar power plant is only about one year compared to five years for a coal or hydropower plant.

4.2 Social and Environmental Burden

Coal is known to be a highly dirty fuel which causes a lot of pollution. It is a known health hazard (http://www.catf.us/resources/publications/files/Dirty_Air_Dirty_Power.pdf). It injures human health at every stage of its life cycle – during mining, transportation, storage, burning and waste disposal. It is known to cause chronic health problems amongst coal miners. Communities near coal mines are adversely impacted by mining operations. During burning coal produces smog, soot, acid rain and other toxic emissions which adversely impact vital human organs like respiratory, cardiovascular and nervous systems. The storage of post-combustion harmful wastes from coal power plants also threatens human health.

Countless studies and reports in different parts of the world highlight the damaging effects of pollutants due to the burning of coal (American Lung Association, 2011). Chinese cities are among the most polluted in the world and coal pollution is the biggest culprit. Dense smog often blankets cities like Beijing, forcing schools to shut down, people to wear masks and farmers to panic over the lack of sunlight. According to a recent collaborative study between Tsinghua University in Beijing and the Boston based Health Effect Institute, burning coal has the worst health impact of any source of air pollution in China and has caused 366,000 premature deaths in 2013 (https://www.nytimes.com/2016/08/18/world/asia/china-coal-health-smog-pollution.html?_r=0). According to the American Lung Association (2011), coal-fired power plants produce more hazardous air pollutants in the United States than any other industrial pollution source. Upon burning, coal releases chemicals into the atmosphere that threaten not only the air Americans breathe, but also the water they drink, the soil they live on and the food they eat.

A recent study by the Mumbai (India) based Conservation Action Trust estimates as many as 115,000 deaths annually due to coal-fired power plant pollution, costing the nation about $4.6 billion. The report also links millions of cases of asthma and respiratory ailments to it (https://www.scientificamerican.com/article/coal-fired-power-in-india-may-cause-more-than-100000-premature-deaths-annually/). A study to assess the health impacts of burning coal to generate electricity conducted by Stuttgart University's Institute for Energy Economics and commissioned by Greenpeace International estimates that air pollution from Europe's 300 largest coal power stations causes 22,300 premature deaths a year and costs companies and governments billions of pounds in disease treatment and lost working days (https://news.mongabay.com/2013/06/burning-coal-responsible-for-over-20000-deaths-a-year-in-europe/).

4.3 Climate Change

Coal is one among three fossil fuels (coal, petroleum and gas). The burning of fossil fuels for energy production is a major cause of increased greenhouse gas emissions, which are responsible for anthropogenic global warming leading to much dreaded climate change. Although Africa's contribution to greenhouse gas emissions is very small, it is known that it stands to suffer more due to the adverse impacts of climate change.

Climate change is a major global concern and the world is seriously engaged to address this scourge. Zambia signed the Paris agreement on climate change on 20 September 2016, which entered into force on 4 November 2016. His Excellency the President of the Republic of Zambia, Edgar Chagwa Lungu during his visit to the Marrakech climate conference, assured that Zambia would bring changes in its legislation in the light of the signing of the Paris agreement on climate change. Zambia now has a National Policy on Climate Change (NPCC) which was launched in 2017.

As part of the Paris agreement, Zambia has submitted its Intended Nationally Determined Contributions (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC). Intention for a low carbon and climate resilient development pathway is clearly enshrined in Zambia's recently formulated NPCC and National Climate Change Response Strategy (NCCRS).

Although the INDC are not legally binding commitments and countries can wiggle their way out of following them, as part of the global community, Zambia is expected to be a responsible nation and to uphold the international treaties and regulations. Unfortunately, at this time, the U.S. under the leadership of Donald Trump has decided to move unilaterally against the global tide on climate change. Nevertheless, commitments under the climate change treaty are likely to become increasingly more stringent and binding in future, as the world needs to tighten up towards its goal of restraining the rise in the earth's temperature to well below 2^{o}C.

Image 1: A solar power plant in South Africa (Author's picture)

5. Global Trends

Climate change concerns are rapidly driving the world away from the use of fossil fuels, towards the increased use of renewable sources of energy. We are in the midst of an energy revolution. For the first time in history, the year 2015 witnessed more than 50% of new power generation in the world coming from renewable energy sources, mainly solar and wind. All major global international organisations like the U.N., the World Bank, the African Development Bank and the Kofi Annan led Africa Progress Panel have been unequivocal in advocating the increased use of renewable energy.

Although coal is a very valuable source of power, as it provides 41% of the current electricity generation worldwide, the world is now weaning away from coal. Consumption of coal has passed its peak and the use of coal is on the decline. Global coal consumption fell by 1.8% in 2015, well below the 10-year average annual growth of 2.1%. As natural gas is much less harmful than coal, some countries are replacing coal by natural gas.

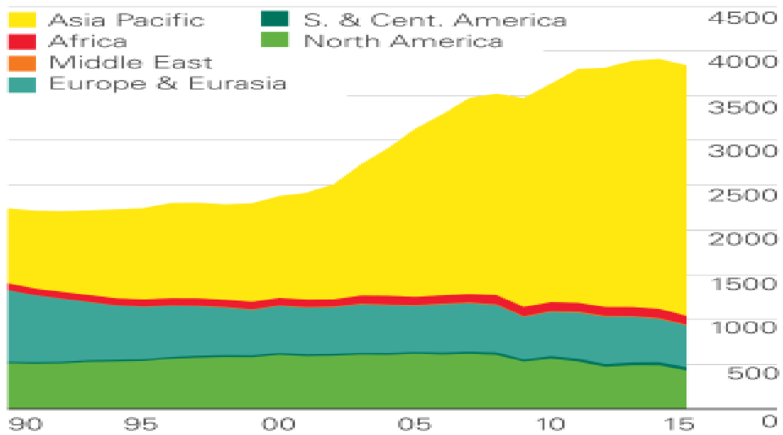

Figure 1: Coal consumption by region (million tonnes oil equivalent) (Source: BP Statistical review 2017) https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf

China, the U.S. and India account for about 70% of global coal consumption. All three of these large coal consumers are now moving rapidly to implement aggressive policies to drive a sustained decarbonisation of their grids. In 2015 in the U.S., 94 coal-fired power plants closed, with a total capacity of over 13,500 MW. Another 41 coal plants were scheduled to close in 2016, with a total capacity of over 5,000 MW. This trend may receive some reversals in the hands of President Donald Trump, but it cannot change international trends and directions.

China is currently the largest consumer of coal in the world. More than 60% of its energy comes from coal. But due to pollution and climate change concerns, the use of coal is on the decline with both imports and domestic production of coal having been reduced in recent years. China has halted work on thirty under-construction large coal power plants with a total capacity of 17 GW. In order to reduce the usage of coal, it is also cancelling 100 GW of coal power plants which are in the permitting stage. These decisions, although very painful due to huge commercial losses, are being taken in view of long term implications. Since coal is the most intense pollutant, some of the coal-fired power plants are being replaced by relatively less polluting natural gas-fired power plants as an intermediate measure.

The South African power utility Escom has also drawn up plans to decommission some of its old coal power plants and reversed earlier decisions to extend their life span. Escom would shut down five old coal power plants, in order to make room for electricity from the Independent Power Producers (IPPs). Sluggish economic growth and moving away from coal towards more renewable energy are some of the considerations leading to these decisions.

Britain is rapidly reducing the use of coal to generate electricity to reduce pollution and harmful emissions (Nature Climate Change, 2017). On Friday 21 April 2017, Britain went without coal to generate electricity for 24 hours for the first time since the industrial revolution. There are currently 16 coal power plants still operating in the U.K. all of which will be closed by 2025. The Digest of UK Energy Statistics (http://go.nature.com/2q80ve7) reports that from 2014 to 2016 the share of coal in the power mix reduced from 29% to only 9%. France and Canada wish to fully withdraw coal power by 2023 and 2030, respectively. Climate change negotiations are evolving. Requirements for greenhouse gas emissions reduction will gradually become more stringent. It is likely that even developing countries will be required to reduce their emissions. Coal does not occupy any room in future energy sustainability.

6. Good Initiatives and the Need to Rethink Coal

Coal has historically been a very useful source of power. Currently the largest share of electricity being produced worldwide is from coal. But, in view of serious environmental, social and climate change impacts of burning coal, the world is moving away from coal and rapidly switching to clean renewable sources of energy, notably solar and wind. Renewable energy has undergone dramatic price reductions in recent years and is now competitive with traditional sources of power. Moreover, the price of renewable energy continues to decline further, whereas the price of electricity from coal is more or less static. Furthermore, the time-frame for a utility scale solar power plant is about one year compared to about five years for a coal power plant. Thus, renewable energy scores on all three fronts.

The Zambian government's swift response to mitigate the power shortfall of 2015/2016 is commendable. With Maamba coal plant and Itezhi-Tezhi on board, together with good rainfall and some power imports, the situation has more or less normalised in 2017. Zambia has good solar resources and solar energy combines well with hydropower. Therefore, the government's new initiative to go for the World Bank Group Scaling Solar program to set up 600 MW of solar power is a highly welcome initiative and a milestone in the Zambian power sector. This will significantly enhance total installed capacity, reduce power shortfalls, attract private investment and enhance power sustainability at a cheaper cost. At the same time the move towards cost reflective tariffs is another highly welcome step which was long overdue. It will help in attracting private investment in the power sector.

Other good initiatives of the Zambian government include the construction of the Kafue Gorge Lower 750 MW hydropower plant, which started again during 2015 after being abandoned earlier in 2011 due to contractual issues. Active construction work is now ongoing and the project is due to be completed in 2020 (http://www.power-technology.com/projects/kafue-gorge-lower-kgl-power-station/). Another large hydropower plant which is attracting attention is the Batoka Gorge, to provide 1,200 MW each to Zambia and Zimbabwe, which is in the early planning stage.

However, the move towards the increased use of coal is full of risks. A common argument generally advanced to support Zambia's position on increased coal use goes as follows: Zambia is still a developing country desperately in need of more power. On a global scale, its contribution to greenhouse gas emissions is negligible. Coal provides a reliable, affordable and abundant source of power. It diversifies the energy mix and forms a good base load to allow for increased use of renewable energy (solar and wind), which is intermittent. Moreover, developed countries have reached a stage of high development through the use of dirty fossil fuels including coal. Zambia should also be free to choose whatever path it takes to develop. Eradication of poverty should take precedence over global issue of climate change.

The 2008 National Energy Policy (NEP) of Zambia seems to provide legitimacy to the increased use of coal for electricity generation, as it aims to increase the contribution of coal as an energy resource and supports the use of coal for electricity generation. However, it may be noted that the global trend has changed dramatically since the 2008 NEP and the policy needs to be re-examined in respect of increased use of coal for electricity generation.

Zambia needs to be mindful of global developments. At a time when the world is moving towards cleaner sources of energy, Zambia seems to have chosen the opposite path. Trying to diversify the energy mix using a highly unsustainable source of power like coal will not help. Simply because developed countries went through a certain developmental path does not necessarily imply that developing countries should choose the same path irrespective of its consequences, especially when alternative options are available. If Zambia did not have any other source of power, there would be no argument about the increased use of coal. The use of coal will damage the health of many Zambians, it will cost more money and it will contribute to global climate change.

Solar power is clean and practically free from any pollution. Admittedly, it is intermittent and requires a base load. But plenty of hydropower provides Zambia with a good base load. As a thumb rule one can add about 50% intermittent power like solar or wind on top of a base load. Since Zambia already has over 2 GW installed hydropower, it can add a total of around 1,000 MW of solar power even under the existing installed capacity. Therefore, solar energy should occupy a much higher proportion in the national energy mix. There is need to undertake a comprehensive study to assess the total solar energy which the nation can commission, as well as identify the points at which solar energy can be generated and fed into the national grid.

The life time of a coal power plant is between 30 and 50 years. The commissioning of new coal power plants could boost greenhouse gas emissions and lock Zambia into fossil fuel intensive energy systems for decades. Zambia will commit to a technology that will become obsolete and the investment may become a dead asset after one or two decades. Going for new coal power plants at this stage will be uneconomical. New investments in coal-fired power plants would be extremely risky in the current global economic, technological and policy scenario. Long-term investments in this risky technology could be acceptable if the country did not have any other choice. But Zambia has other choices and so it must rethink its strategy on coal.

Zambia should undertake a comprehensive study on the long-term socio-economic and environmental implications of various sources of power, especially coal power vs. renewable energy. It should also undertake studies on grid absorbing capacity. These studies should allow it to draw up a more comprehensive plan for a sustainable energy future. It appears likely that hydro, solar photovoltaic, concentrating solar power, wind energy and energy conservation will be sufficient without recourse to more coal power for securing a sustainable energy future for Zambia.

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